Message

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Subject: Red Hill Groundwater Water Meeting Follow Up

I hope you find these notes helpful. I have broken my notes into three major topic areas as follows, with a sum-up at the end:

1. Data and CSM Presentation
2. Groundwater Modeling Presentation
3. LNAPL Modeling / Analysis Presentation

I have more detailed notes on many aspects of the meeting, to specific slides, that I have not included. I also have detailed notes from the visit to the quarry that I have not included. The comments below represent a higher-level summary of all of my notes to-date, with a couple of specific examples included. I have sent these notes to everyone who was on the "invite" for the call yesterday, Tuesday. Please do pass on to anyone else who should be a recipient.

Thanks - Matt

Data and CSM Presentation

I think it is important to recognize the good fundamental data collection that has been completed in the last couple of months (at least since I have been involved) and some of the evaluation and reporting of those data, using the new West Bay as an example, which appears to have been installed and tested successfully. We all agree that data are lacking, to support any analyses at the moment, so the progress on data collection and more thorough analysis is laudable.

That said, the integration of these data and the development of the Conceptual Site Model (CSM) seems to be placing emphasis in some areas that appear to be less critical, and not placing sufficient emphasis in areas that appear more critical to the decisions to be supported. For example, the emphasis placed on the quarry area recharge appears to outweigh its likely influence on groundwater and potential contaminant migration with the underlying basalts: it likely should be part of the CSM, but may reveal itself not to justify the amount of time spent on it at this point. This is particularly true given the meeting at the quarry which suggested return-flows (non-consumptive use) may be substantially less than at first assumed. On the other hand, there does not at this point seem to be adequate attention given to the likely impact of the basalt stratigraphy on flow, transport and fate of any potential contaminants. There are ample studies from other similar basalt regions indicating that there is a high potential for connected, preferential flow-paths that can enhance the distance and reduce the time for migration versus idealized, homogeneous (EPM-type) systems and assumptions. I have compiled some related documents for reference which can be shared if desired. This aspect of the CSM at this pint seems to be receiving insufficient air-time. Note that in the meeting, it was discussed that GSI/AECOM is developing a 3D geologic model, but this was not presented or discussed further as to level of detail, content, environment, etc. This would, when presented/shared, help greatly to understand the relative emphasis being placed on different aspects of the CSM.

Finally, the water level mapping presented to-date is useful in general terms, but could be more informative if tackled in more rigor. For example, water level mapping can be used to test hypotheses in the area of Red Hill by evaluating the role that a potential high-transmissivity feature would have on the map, and making related water balance calculations. Alternatively, residuals from the water level mapping can help identify areas of particularly strong departure from the underlying conceptual site model, that can point to heterogeneity, stresses, and other features that warrant inclusion within the groundwater model.

As the data are gathered it is important that they be used to help validate or test aspects of the CSM: however, this is difficult to do if the CSM does not adequately describe and incorporate these features or processes.

Groundwater Modeling Presentation

It was encouraging to see the results of draft particle tracking analyses based upon the current progress of the interim steady-state groundwater flow model. The scenarios presented were both illustrative and revealing in terms of how a model, once further developed, may be used to assess the zones of contribution to supply wells (shafts) under alternate pumping scenarios. Several aspects of the model development appear to be progressing in the right direction as anticipated and required by the AOC, to provide a basis for the final flow model and subsequent transport analyses.

However, there are aspects of the model development, construction, and application that appear to be lagging behind expectations currently. These include the following:

1. The progress of the calibration (3-steady-state scenarios) and validation (to transient data) is slower than anticipated, and remains largely qualitative at this stage. This may ultimately suffice to meet the immediate need of the interim model deliverable (that is debatable), but then a great deal of work will then remain to enhance the model for purposes of detailed groundwater flow and potential contaminant migration modeling and scenario analysis.
2. The upgradient (mountain-front) boundary condition may exert too strong an influence on flow and migration patterns, acting to enhance or over-prescribe the propensity for flow to occur "Mauka to Makai" regardless of other factors (recharge rates, pumping, etc.). This boundary condition in particular (although in concert with the lateral boundaries) should be viewed with caution and evaluated via calibration-constrained sensitivity analyses. This was also revealed, potentially, by the water budget analysis presented (AECOM slide 54) because springflow was assumed low in 2015 at time of higher (than 2017, anyway) recharge which seems counterintuitive: this suggests that the assumption of constant inflow along the NE boundary may be problematic, and this is a concern because it is a large and influential fraction of the budget.
3. Unfortunately, the three-point gradient method which is useful in many other sites, will be largely hopeless here, given the geology. Head-differences, as noted by Sorab, may be more useful, however, there is still likely to be substantial misfit in the calibration. This will be particularly so when using a greatly simplified model structure and geologic representation as is currently the case. An example is RHMW-07 (AECOM slide 74), which shows changed elevations in the data but not in the model.
4. Underlying geologic model: at this stage, this appears very simplified, representing essentially only major Hydrostratigraphic Units (HSUs) that differentiate basalt from sapprolite from carbonates, and not differentiating within these first-order HSUs. As for item (1), this may ultimately suffice to meet the immediate need of the interim model deliverable (that is debatable), but again a great deal of work will be required to bring the interim model to a final status incorporating HSUs at the scale that may be pertinent to potential subregional contaminant transport and fate rather than the scale of a regional

water-budget analysis tool. As noted, it is unclear how this will be accomplished: the unstructured grid code is perfectly suited to local-scale definition of model parameters, within a regional model exhibiting a more "EPM-type" parameterization. Indeed, there are methods available that are suitable for representing basalt sequences just like those seen at Red Hill and beyond, for this purposes. It is however unclear how and to what extent this level of HSU representation will be incorporated in the model, but this is important to any transport and fate analysis. In the end, I suspect what will be needed will be a "model within a model" approach, at least in terms of the level of parameter detail, with simplified regional parameterization, and detailed local parameterization (see below).

5. It is unclear what the current model does, and does not, incorporate in terms of the developing underlying data set and CSM: for example, which of the sapprolite valley fills are represented, and to which depths, are they consistent with the CSM and with the new West-Bay or not yet? It would help when the model is being presented (and when documented in the pending Tech Memo) for this to be made very clear. This might be achieved for example via versioning if it does not become too complicated (i.e., a version number for the model, and version number for the underlying CSM and I presume 3D geologic model in whatever form it is in).
6. It is unclear from materials presented to-date, how the model will be used beyond the activities and objectives outlined for the AOC (with particular focus on the zones of contribution of the various water supply shafts). A different approach to model scenarios analysis is needed when transitioning from water-balance type analyses such as average zones of contribution, to "risk-analysis supporting" analyses such as potential impact scenarios using contaminant transport and fate. Importantly, the model structure has to be capable of supporting such "realistic" analyses, and at the present time it is not.

Given the path forward, and the likely application of the model to evaluate scenarios, some combination of [a] locally-detailed, regionally-simplified aquifer parameterization is going to be required, and then [b] a calibration-constrained predictive analysis approach is going to be warranted. It is important to realize that these approaches range from the very simple to the highly complex, and at this stage (or perhaps at any stage) the highly-complex methods are not warranted because there are insufficient data to discriminate between parameterizations, scenarios and likelihoods. So the modeling approach may ultimately become, in a calibration-constrained setting: *are there conditions consistent with the data we have, under which an unacceptable impact can occur to [a] a specific receptor or [b] groundwater in general*. This approach is a little more manageable than a full-blown monte-carlo type approach, is fairly easily set up and fairly easily communicated. The locally-detailed, regionally simplified aquifer parameterization may be achieved for example via appropriate, informed, interpolation of the available basalt stratigraphy using a method designed for such systems (i.e., a structure-imitating approach as opposed to a pure statistical approach).

<u>LNAPL Modeling / Analysis Presentation</u>

I am providing limited comments here, as I defer to Gary Beckett on this topic.

The concept of the "screening level" calculations presented seems to be an ok starting point to get some basic ideas and concepts on the table (setting aside the actual results obtained, which are questionable). But the number of limitations in such an analysis to site-specific application is so great, that I don't think the analysis can be taken much beyond where it was left-off at the conclusion of the January 11th meeting. Such an analysis is highly difficult to tie to actual field data and conditions and as such it still leaves wide open the concept of how to reasonably cast the concept of releases into the more physically-realistic release-transport-fate-risk framework that is being developed. Based on the presentation, this seemingly hasn't yet been thought through, and as a result this may be the opportunity, then, to provide guidance and suggestions on what would be more acceptable an approach to the regulatory group that moves beyond the simple

screening-level. What is also disconcerting is that screening level analyses are assumed to be *de-facto* "protective", but on many occasions there is no guarantee of that at all, because some of the simplifying assumptions are too gross: this was an example of such a case, in my opinion, where the box calculations appeared to suggest (as presented) there is little to no potential for groundwater impact, whereas the converse is amply demonstrated by the data. My concern here would be that presenting this box-model at a public meeting offers an over-simplified and misleading portrayal of the potential for impacts, that would have to be "walked back" later on by more rigorous and site-specific methods of analysis. In summary, then, I think the box-model approach was useful to get people thinking about *some* of the important factors at play, but it neglects many other factors, can be misleading, and doesn't really have many legs to take it much beyond what was presented January 11th. I will finally also note that there was something clearly wrong with the results of the Monte-Carlo: during questioning AECOM/GSI agreed that the 10:90 percentile intervals were far too tight given the input ranges and I suspect that the revised numbers will be quite different, including some more and less "protective" conclusions approaching the bounds.

Overall Impressions

Overall, the data collection is very good; the specific analysis of the data so far is good; the development of the CSM seems weak and not sufficiently focused or inclusive; the development of the groundwater model is heading in the right direction but remains simplified and currently unsuitable for defensible predictions; and the presented LNAPL analysis is a curiosity but inadequate to the needs of the project.

With regard the overall objective, it is unclear to me how the initial box-model of LNAPL will feed into the overall release-transport-fate-risk framework that I understand is in the process of being developed. I believe Gary has ideas in regard the LNAPL, and I have ideas in regard to how to appropriately structure the groundwater model so that one could incorporate the results of more physically-plausible LNAPL modeling into an appropriately-structured groundwater model for more informative and defensible analysis. In particular, I do think that some local-scale illustrative depictions or calculations for LNAPL and groundwater movement would be valuable to highlight the effects of sub-regional-HSU scale structure and LNAPL release characteristics on the possible transport and fate both of LNAPL and leading-edge dissolved constituents. This would contrast with the approaches taken / presented so far, and would at a minimum highlight how different things are when you evaluate transport via [as presented] a link between two simplified homogeneous EPM model (one for LNAPL and one for groundwater) versus when transport and fate are evaluated via two more realistically-parameterized models. As noted above, this would use a more locally-detailed parameterization achieved via interpolation of the available basalt stratigraphy using a structure-imitating approach.

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